



THE IMPACT OF DAYTIME PHYSICAL ACTIVITY ON SLEEP QUALITY: A COMPARATIVE STUDY USING WHOOP DATA

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ABSTRACT

This study explores the relationship between daytime physical activity and sleep quality in adolescents, focusing on metrics such as total sleep time, deep sleep duration, and sleep efficiency. Using a WHOOP wristband for data collection, the research compares the sleep patterns of a 15-year-old male participant during an active week (playing soccer) versus a sedentary week. Results indicate that physical activity significantly improves sleep metrics, with the active week yielding longer sleep durations, higher sleep efficiency, and more restorative deep sleep. These findings align with existing literature that links exercise to improved sleep quality. Despite the promising results, the study acknowledges limitations, including a small sample size, short duration, and uncontrolled external factors such as diet and stress. Future research should incorporate a more diverse and extensive sample group, longer observation periods, and control over additional variables to validate these findings. This study highlights the potential of incorporating regular physical activity into daily routines to address sleep issues, improve well-being, and enhance overall performance in adolescents.

KEYWORDS: Physical Activity, Sleep Quality, Adolescents, WHOOP Wristband, Deep Sleep Duration, Sleep Efficiency

INTRODUCTION

According to The National Sleep Foundation (2023), quality sleep is important as it affects memory consolidation, learning, and problem-solving, and poor sleep is associated with various negative outcomes, including impaired concentration, mood disorders, and increased risk of chronic health issues such as cardiovascular disease (Cardiovascular Disease, 2022). Sleep plays a much more important role in an adolescent, as it influences growth, development, and academic performance. The CDC (2022) stated that most people, especially teenagers, need about eight to ten hours of sleep per night, but many do not get that much. The reasons often have to do with academics, social life, and irregular sleep routines.

For years, the health benefits of physical activity have been very well known, one of them being that it helps promote better sleep quality. Improvements in sleep have been shown after people perform aerobic exercises throughout the day; some of these improvements include sleep onset, sleep duration, and sleep efficiency (Smith, 2021). The Sleep Foundation (2021) stated that physical activity helps increase the body's production of adenosine, a compound that promotes sleepiness, and also lowers the levels of a hormone called cortisol, which, although not a direct disruptor of sleep, can cause other types of sleep deprivation such as stress. Furthermore, regular exercise plays a role in keeping the circadian rhythm stable, which is the body's internal clock responsible for regulating sleep and wake cycles, in a healthy and high-functioning state (American Academy of Sleep Medicine, 2022).

Despite this link between exercise and better sleep, most literature has been directed to generalized populations or adults. Very few studies to our knowledge have examined the

effect of daytime physical activity on adolescents' sleep quality, specifically using wearable technology. For this reason, I chose myself as the participant and consistently participated in soccer three times for one week, measuring my average time asleep. For the second week, I did not participate in any physical activity.

Research Question: To what extent does engaging in a week of soccer affect the sleep quality of a 15-year-old male, as measured by total sleep time, deep sleep duration, and sleep efficiency, compared to a week without physical activity, measured by a WHOOP wristband?

Literature Review

Several studies have shown that physical activity, specifically aerobic exercise, leads to better quality sleep. Regular exercise may help a person fall asleep faster, have a longer sleep duration, and sleep through earlier and longer stages of sleep (American Academy of Sleep Medicine, 2022). According to the Sleep Foundation (2021), a study shows that moderate-intensity aerobic exercises (jogging, swimming) improve sleep onset and enhance the amount of restorative sleep, especially the amount of slow wave sleep (deep sleep), which is essential for physical recovery and mental regeneration. By their very nature, these types of activities put intense physical effort on the body, which may help it to relax, go to sleep more naturally and efficiently (Smith, 2021).



Figure 1: WHOOP Wristband

Recently, the widely popular WHOOP wristband (shown above) has been an invaluable tool to help sleep research. Continuous, non-intrusive sleep pattern monitoring and real-time data on key sleep metrics such as total sleep time, deep sleep, and sleep efficiency can be achieved using this device. In particular, WHOOP is known for its ability to simultaneously track both levels of activity and recovery, which makes it especially effective for studies that look at how physical activity and sleep are related to one another. Miller (2022) showed that WHOOP could be used to accurately track fluctuations in sleep quality from being exercised, providing insights into the relationship between physical activity and sleep architecture. This wristband offers an easy way to watch individual sleep patterns and make more accurate analyses without requiring in-depth sleep studies or polysomnography.

Wearable sleep technology has shown its potential in assessing how sleep changes with exercise and has stimulated studies to understand sleep changes as a function of exercise in adolescents. Adolescents have a particular vulnerability to sleep disturbances due to rapidly developing bodies, academic pressures, and social demands. Teenagers who face poor sleep can also face many adverse effects, such as poor school performance, behavioral problems, and future health problems (CDC, 2022). Ensuring that physical activity at school, such as soccer, affects sleep for adolescents could tell us a lot about how to improve sleep health.

METHODOLOGY

Participants: This study includes a 15-year-old male participant with a consistent routine of physical activity. The participant plays soccer for 2 hours on Monday, Wednesday, and Thursday and usually has difficulty falling asleep at night. A WHOOP wristband is used to track sleep patterns.

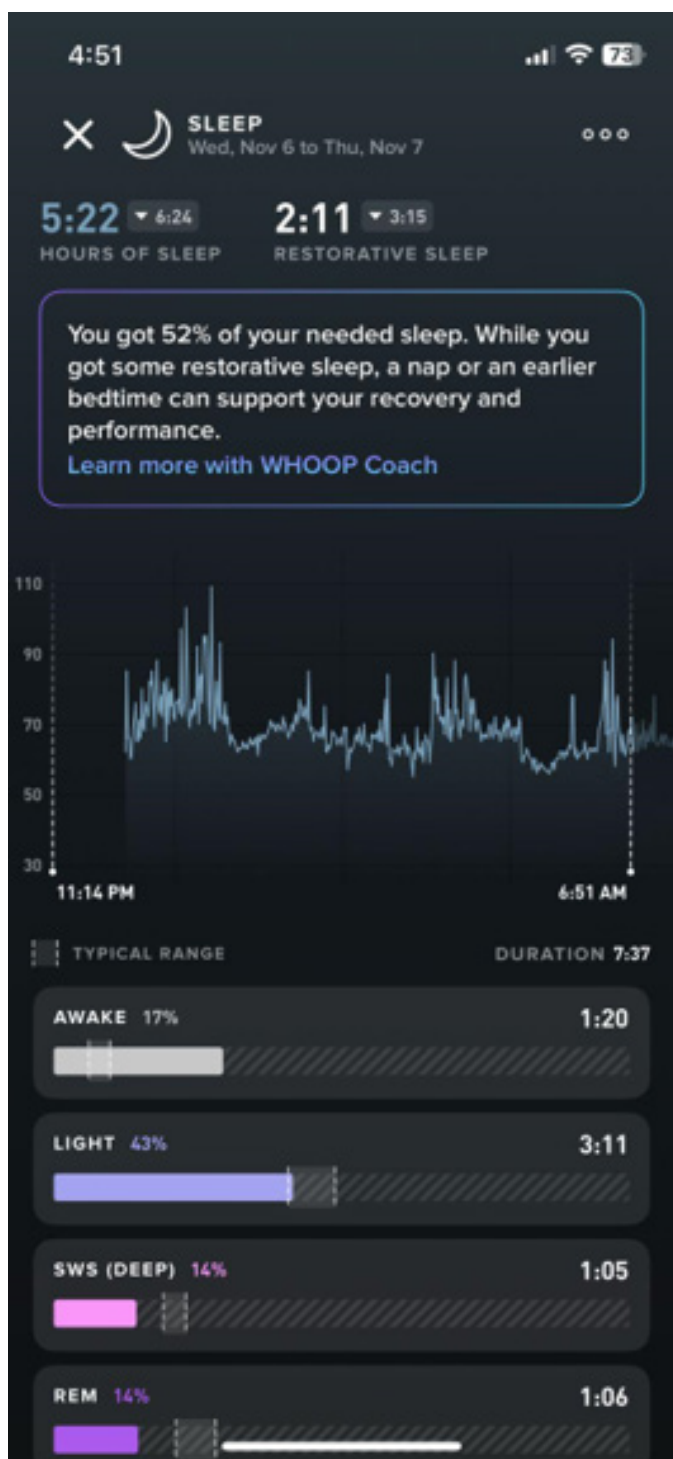
Independent Variable: The independent variable is indulging in physical activity (specifically soccer) throughout the first week. The participant will be playing 2 hours a day on Monday, Wednesday, and Thursday. In the second week, the participant will not be participating in any physical activity.

Dependent Variables:

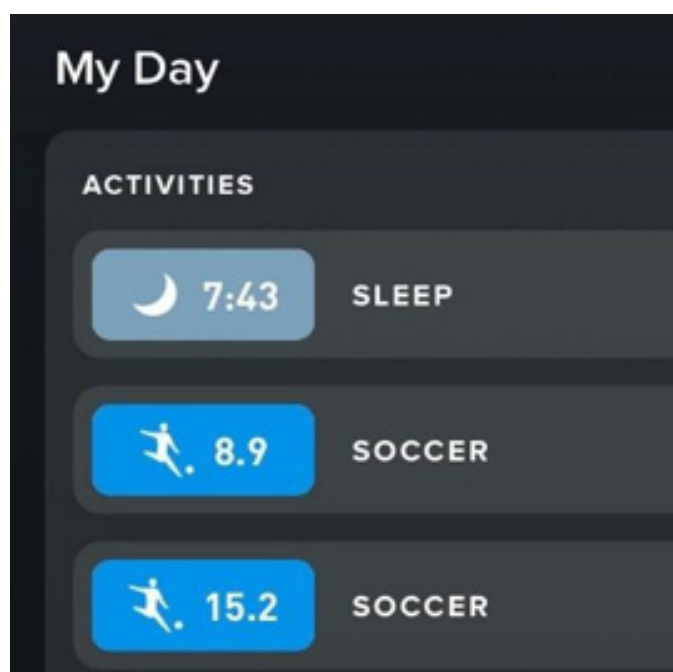
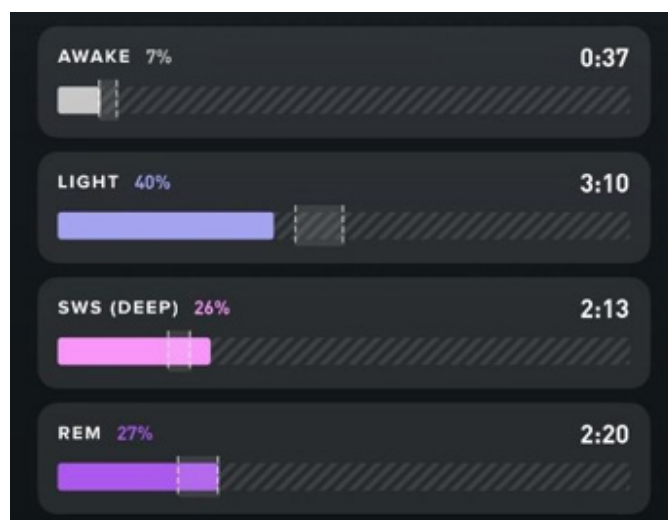
- **Total Sleep Time:** The time spent asleep by the participant each night, as recorded by the WHOOP wristband.
- **Deep Sleep Duration:** Measured by the WHOOP wristband, the amount of time the participant spent in 'deep' (slow wave) sleep, which is considered the most restorative stage of sleep.
- **Sleep Efficiency:** Measured as a percentage using the WHOOP wristband is the ratio of time the participant spends asleep to time spent in bed.

Procedure:

1. Ensure the participant maintains a consistent daily routine, including waking up at 6:30–7:00 AM.
2. Ensure any caffeine and naps are avoided to limit exposure to sleep interference.
3. Calibrate the WHOOP wristband and confirm baseline sleep metrics.
4. Make sure that the information in the wristband tracks total sleep time and deep sleep duration and sleep efficiency are accurate.
5. Divide the study period into two separate weeks: With soccer or without.
6. Designate Week 1 as the active week with soccer and make Week 2 a control week in which the participant does not participate in any physical activity.
7. For Week 1, have the participant play 2 hours of soccer Monday, Wednesday, and Thursday from 4 to 6 PM.
8. Ensure the participant is restricted from further exercise or highly physical activity to avoid inaccurate results.
9. Using the WHOOP wristband, record the participant's daily bedtime and wake-up time.
10. Record the total sleep time, deep sleep duration, and sleep efficiency data each night from the WHOOP wristband.
11. In week 2, ensure the participant does not indulge in any physical activity.
12. Record bedtime, wake-up time, and nightly sleep metrics throughout Week 2.
13. Using the WHOOP wristband, record the participant's bedtime and wake-up time each night.
14. Verify WHOOP data works by cross-referencing them with manual observations.
15. Calculate weekly averages for all sleep metrics including total sleep time, deep sleep duration, sleep efficiency, etc.
16. Compare the average sleep metrics of Week 1 and Week 2 to see how physical activity affects sleep quality.



What one of the days look like without physical activity



What one of the days look like with physical activity

Processed Table

Metric	Week 1 (With Soccer)	Week 2 (Without Soccer)
Average Bedtime	11:26 PM	12:11 AM
Average Wake-up time	6:53 AM	6:58 AM
Average Total Sleep Time	7 hours 14 minutes	5 hours 03 minutes
Deep Sleep Duration	2 hours 10 minutes	1 hour 45 minutes
Sleep Efficiency	88%	78%

Interpretation

Total Sleep Time: Average total sleep time was 7 hours 14 minutes for the week with soccer versus 5 hours 3 minutes for the week without soccer. This shows that with soccer there is a rise in sleep duration that is consistent. We can also infer with research that physical activity can enhance sleep time.

Deep Sleep Duration: There was notably more of that deep sleep during the soccer week: 2 hours 10 minutes versus 1 hour 45 minutes during the week without any physical activity. These findings agree with studies that exercise improves slow wave sleep and overall restorative sleep (Smith, 2021).

Sleep Efficiency: Sleep during the week of physical activity had better sleep quality, as the sleep efficiency was higher (88% vs. 78% without physical activity). Exercise has been shown to improve sleep quality, which has also been linked to increased sleep efficiency (which signifies a greater portion of restful sleep) (American Academy of Sleep Medicine, 2022).

Limitations

Some limitations should be noted throughout this experiment. While this study offers useful information in understanding the relation between daytime physical activity and sleep quality, the experiment might be subject to misclassification bias. The first limitation of the study is the sample size; this experiment was only tested on one participant, which may conclude different results from other people. The results would have been stronger if the sample was more diverse and larger. The study was also short, just two weeks, so the experiment may not include long-term effects or the long-term variation in sleep patterns.

Another limitation is the control of other possible factors that can influence sleep metrics, such as daily stress, diet, and environmental changes. The effects of physical activity alone are hard to isolate from all of these external variables because they were not measured or accounted for. Additionally, unlike polysomnography, the WHOOP wristband is a reliable sleep tracker, but it may not provide as accurate results in sleep stage tracking; it may miss many sleep behaviour nuances.

Future studies should expand the group to more participants, observe for a longer period of time, and control for other outside factors, such as lifestyle habits and stress. A combination of wearable devices and clinical methods would also allow for a more comprehensive understanding of exactly how physical activity impacts sleep.

CONCLUSION

In conclusion, these results suggest that regular physical exercise improves sleep quality, such as sleep duration, deep sleep, and sleep efficiency. These results show a contrast between the week with soccer versus the week without physical activity. In the week with soccer, there was a big jump from the week without soccer (an hour on average of total sleep time over the week without soccer). According to the National Sleep Foundation (2023), this conforms to previous research indicating that exercise can heavily lead to longer sleep duration by increasing physical fatigue, facilitating an easier and longer sleep duration phase leading to more efficient restorative stages. This further matches previous results from the American Academy of Sleep Medicine (2022), suggesting that high-intensity exercise may increase slow wave sleep, the most restorative part of sleep.

Furthermore, while sleep duration and deep sleep were found to

be similar with whether soccer was played on the week or not, sleep efficiency was also drastically higher on the week with soccer by 10%, suggesting that sleep on the week with soccer was, with all things considered, more restful and undisturbed. This shows that physical activity not only optimizes the amount of sleep but also improves sleep quality.

Overall, these results support the hypothesis that daytime physical activity, particularly high-intensity sports such as soccer, is associated with better sleep. Regular physical exercise may also be a beneficial intervention for others, such as students and professionals, who may have problems with sleep difficulties, because not only can it help to increase sleep duration, but also to improve sleep quality. The importance of this research is that physical activity can help sleep, which results in better daily performance and well-being. However, even though the results supported the claim that physical activity can help sleep, the results from this study should be interpreted with caution, given the small sample size and short duration. One of the reasons being that during the experiment we used a consistent routine and did not have control over other variables (diet and stress, for example), leading to the results. These findings need further validation with a larger sample size and longer observation period, and with control over more lifestyle factors.

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